

**Report
of the
Committee Appointed
to
Investigate the
Dangers Arising from
Coal-Dust in Indian Mines**

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REPORT

of the Committee appointed to investigate the dangers arising from coal-dust in Indian Mines

By the Government of India, Department of Industries and Labour, in Resolution No. M.-498, dated 24th July 1923.

CONSTITUTION OF THE COMMITTEE

Chairman :

Mr. R. R. Simpson, Chief Inspector of Mines in India.

Members :

Mr. J. B. Wardlaw, nominated by the Indian Mining Association ;
Mr. J. G. Foster, nominated by the Indian Mining Association ;
Mr. H. C. Read, nominated by the Indian Mining Federation ;
Mr. H. K. Nag, nominated by the Indian Mining Federation ;
Mr. G. Naysmith, nominated by the Colliery Managers Association in India ;
Mr. J. Thomas, nominated by the Mining and Geological Institute of India ;
Mr. J. H. Lang, Inspector of Mines in India ; and
Mr. D. Penman, Inspector of Mines in India (also Secretary).

In April 1924, Mr. J. G. Foster, before proceeding on leave, resigned, and Mr. P. Bates was nominated as his successor by the Indian Mining Association.

TERMS OF REFERENCE

To enquire into the danger of explosions of coal-dust in Indian coal mines ; to make experiments on different kinds of coal-dust with a view to determine their liability to explode or otherwise ; and to report what means, if any, are necessary or desirable to provide against the risk of coal-dust explosions in Indian coal mines.

INTRODUCTORY

In our investigation into the problems arising out of the terms of reference we have been confronted with the difficulty that neither the funds nor the staff at our disposal would permit of an inquiry in any respect similar to the elaborate investigations which have been carried out in other countries. We do not, however, think it necessary, to effect

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the purpose for which we have been constituted, that an inquiry on such a scale should be attempted. The fundamental facts related to the theory of the explosibility of coal-dust have already been adequately determined elsewhere and are of universal application. It appears to us, therefore, to be sufficient to carry out similar tests, but on a smaller scale, to ascertain in what respects conditions in Indian mines compare with those in the mines of other countries and in what manner and to what extent the conclusions arrived at by other experimenters are applicable in this country. In this, our first report, we discuss briefly some aspects of the problem and indicate in what directions we propose further to prosecute our investigations.

EXPERIMENTAL EVIDENCE OF THE EXPLOSIBILITY OF COAL-DUST

2. The explosibility of fine coal-dust under certain conditions has now been established beyond all doubt. Experimentally, in tubes, and in specially prepared underground galleries, violent explosions have been produced from coal-dust without the presence of any inflammable gas. Much experimental research has been done on the subject in Great Britain, United States of America, France and other European countries. The theory that fine coal-dust is capable of forming an explosive mixture with air was advocated by Professor W. Galloway as long ago as 1875. Previous to that in reports on explosions at Wallsend Colliery in 1803, and at Haswell Colliery in 1844 (both in England) it had been pointed out that fine coal-dust had apparently played a part in the propagation of the explosions. In 1876 Sir Henry Hall carried out a series of experiments in an adit level, 135 feet long, and obtained ignitions. Later in 1891, and again in 1893, he obtained ignitions in a disused shaft, 150 deep and 7 feet in diameter. Coal-dust was thrown down the shaft and a gunpowder shot from a cannon placed at the bottom of the shaft was discharged into the dust cloud. Over 100 experiments were carried out on dusts from a large number of seams and in 55 per cent. of the tests ignitions occurred. During 1893-5 a Committee of the North of England Institute of Mining and Mechanical Engineers carried out tests in an iron tube, 3 feet in diameter and 101 feet long. An exhaustive series of experiments on a large scale were commenced in 1908 under the direction of a Committee appointed by the Mining Association of Great Britain*. The tests were carried out in a gallery about 600 feet long constructed of boiler shells, 7 feet 6 inches in diameter. The gallery was erected on the surface near Altofts Colliery, Normanton, Yorkshire, England. These experiments were conducted under the superintendence of the late Sir William E. Garforth on dust from the Silkstone seam, and resulted in many violent explosions.

3. In 1911 a Committee was appointed by the Government of Great Britain to continue the experiments initiated by the Mining Association. The experimental gallery was removed to a new site at Eskmeals, Cumberland, where, during the year 1911-16, an exhaustive series of tests was carried out. The results of these tests and the conclusions drawn from them are contained in the Reports submitted by the Committee.† The tests at Altofts and Eskmeals conclusively demonstrated that fine coal-dust under certain conditions and in the entire absence of any inflammable

* Record of first series of the British coal-dust experiments 1910.

† Reports of the Explosions in Mines Committee (Reports 1 to 7, 1912-16.)

gas is capable of producing an explosive mixture which when ignited will produce a violent explosion. In some of the tests the violence was so great that some of the boiler shells were shattered into fragments and the pieces hurled into the air.

4. In 1911 the United States Bureau of Mines constructed an experimental mine for the purpose of carrying out tests on the explosibility of coal-dust. The mine consisted of two parallel day drifts in a seam known as the Pittsburgh Bed which, at the site chosen, outcrops on the side of a hill. The drifts were connected in the seam at intervals. Originally they were about 750 feet long, but later the length was increased to about 1,200 feet and in addition a number of galleries were added. In some of the preliminary experiments ignition was obtained from a blown-out shot in the coal, but in the later tests the standard method of initiating an explosion was by means of a shot fired from a steel cannon placed at the inner end of one of the main drifts. Many violent explosions were obtained*.

5. In addition to demonstrating beyond any doubt that coal-dust is explosive, it was shown in the tests carried out in Great Britain and America that fine coal-dust could be rendered innocuous by the admixture of a sufficient proportion of water or of incombustible dust. Experiments and demonstrations at the British coal-dust testing station at Eskmeals and at the experimental mine in the United States are still being carried out, largely for propaganda purposes to convince mining engineers of the destructive effects of a coal-dust explosion and the necessity for taking every possible precaution to avoid its occurrence in a mine. Mention might also be made of the experimental work which has been done in Austria Germany and France, and in the latter country particularly by M. Taffanel

EVIDENCE OF THE EXPLOSIBILITY OF COAL-DUST FROM COLLIERY EXPLOSIONS

6. The following is a brief record of some of the explosions in coal mines which have been attributed to coal-dust :

(1) *Explosion at Seaham Colliery, England, in 1880. (164 lives lost.)*

This explosion was caused by a blown-out shot which ignited coal-dust. The explosion was confined to the main haulage roads.

(2) *Explosion at Altofts Colliery, England; in 1885. (22 lives lost.)*

This explosion was caused by a blown-out shot and originated on a haulage road which was also a main intake airway. The explosion traversed three main intake airways which contained abundant coal-dust for a distance of nearly 2,000 yards. The flame did not traverse other roads which were less dusty or in which the coal-dust was contaminated by stone-dust.

*First series of coal-dust explosion tests in the experimental mine by Messrs. Rice, Jones, Egy and Greenwald, Bulletin 56, United States Bureau of Mines, 1913.

Coal-dust explosion tests in the Experimental Mine 1913-18, inclusive, by Messrs. Rice, Jones, Egy and Greenwald, Bulletin 167, United States Bureau of Mines.

(3) *Explosion at Elemore Colliery, England in 1886. (28 lives lost.)*

This was a pure coal-dust explosion originated by a shot in a main haulage road.

(4) *Explosion at Cammerton Colliery, England in 1893. (2 lives lost.)*

This mine had been working for over a hundred years without gas having been reported. Naked lights were used. The explosion was caused by an overcharged and badly placed shot, and originated in a main haulage road which was very dusty. It extended for a distance of 1,260 yards.

(5) *Explosion at Darran Colliery (South Wales, England).*

A charge of 6 ounces of explosive was exploded on a stone without a hole being drilled. An explosion of coal-dust resulted.

(6) *Explosion at Orwell Colliery, Wigan, in 1901. (4 lives lost.)*

A charge was exploded on a wheel in order to break up the wheel. An explosion of coal-dust followed.

(7) *Explosion at the Courrieres Collieries (France) in 1906. (1,100 lives lost.)*

This explosion originated in a heading and was supposed to have been caused by the explosion of a misfired charge which was being cut out. A workman, it is thought, struck the detonator with his pick, so firing the charge. The dust in the heading was ignited and the explosion spread through several interconnected seams and collieries.

(8) *Explosion at Wingate Grange Colliery, Durham, England, in 1906. (21 lives lost.)*

This was pure coal-dust explosion caused by the firing of a "permitted" explosive.

(9) *Explosion at Dinas Colliery, South Wales, in 1907. (7 lives lost.)*

A shot of gunpowder fired on a main haulage road caused an explosion of coal-dust.

7. Other instances of explosions initiated and propagated by coal-dust might be given, such, for example, as the explosions at Norton Hill Colliery, Somersetshire, in 1908, West Stanley Colliery, Durham, in 1909, and Pennant Hill Colliery, South Staffordshire, in 1913. In a single year (1907) in the months of January and February and again in December no less than eight coal-dust explosions occurred in coal mines in the United States of America causing the death of 830 persons. In addition there exists a vast array of evidence to show that in most extensive explosions coal-dust has been, if not the primary cause, certainly the propagating agent of the explosion. In many instances the explosion has originated through an accumulation of firedamp and, but for the presence of fine coal-dust throughout the workings of the mine, would probably have been confined to a comparatively small area and have done relatively little damage. Unfortunately the initial explosion of firedamp raised the fine coal-dust into the air and the flame was thus fed and propagated far beyond the limits of the accumulation of firedamp. Amongst explosions

of this nature might be mentioned that at Senghenydd Colliery, South Wales in 1913, when over 400 lives were lost, and more recently the explosion at the Haig pit,* Cumberland, England.

8. In a modern coal mine under normal working conditions it is hardly possible for an explosion of firedamp unaided by coal-dust to extend over a large area. The requirements of legislation and the exigencies of working conditions render it extremely improbable that any large body of inflammable gas would be allowed to accumulate in the working places. When, therefore, as has happened on many occasions, an explosion occurs in a working place and extends not only beyond the boundaries of that place but perhaps throughout the whole mine, including the intake airways where an explosive percentage of firedamp is a practical impossibility, it is clear from that fact alone that the chief propagating agent has been coal-dust.

EVIDENCE OF THE EXPLOSIBILITY OF COAL-DUST IN INDIA

9. The available evidence as to the explosibility of coal-dust in Indian mines is meagre. Although there have been several explosions, so far as we are in a position to judge, it is clear in only one instance, namely, the explosion which occurred at Parbelia Colliery on January 4, 1923, that fine coal-dust was the predominant agent in the explosion. In the explosion which occurred at Khost Colliery (Baluchistan) in 1908 the evidence pointed to the explosion having been initiated through an ignition of firedamp. It is probable, however, that coal-dust was an active agent in the propagation of the flame†. The explosions which occurred at Kendwadih Colliery (Jharia coal-field) in 1911 and at Chowrassie Colliery (Raniganj coalfield) in 1913 were clearly explosions of inflammable gases which had either accumulated in the ordinary way or had been distilled from burning coal‡. What was probably an ignition of coal-dust occurred at the Sijua Colliery (Jharia coal-field) on 1st February 1921². The ignition was brought about by the concussion and flame from a round of ten shots fired simultaneously or in rapid succession. The extent of the working was small and only a feeble flame ensued. Three persons were burnt, but none of them died.

10. The explosion at Parbelia Colliery on January 4, 1923, which resulted in the loss of 74 lives, and was the subject of an inquiry under the Indian Mines Act, 1901, was undoubtedly due to coal-dust. This was made clear in the report of the Committee of Inquiry³. The seam in which the explosion occurred is the well-known Dishergarh seam, one of the richest seams found in India. The seam gives off firedamp, and inflammable gas had been found in the colliery from time to time. From the evidence obtained at the inquiry, however, and the condition of the mine the Committee came to the conclusion that "if gas was present at all it can have been present only in a very small quantity. In any case gas did not play an important part in the explosion". It was proved that the explosion was caused by a faultily placed shot which was discharged

* *Report on Haig pit explosion, Mines Department, Great Britain, 1922.*

† *Report of Chief Inspector of Mines in India for 1908.*

‡ *Reports of Chief Inspector of Mines in India for 1911 and 1913.*

² *Report of Chief Inspector of Mines in India for 1921.*

³ *Published in Bihar and Orissa Gazette of 4th April 1923.*

and blew through the rear of the shot-hole into a narrow gallery which had been previously driven in the top part of the seam and which contained fine coal-dust in abundance. Mr. D. Penman* has made some comments on this explosion which merit attention.

There are certain points worth noting in connection with the explosion at Parbelia Colliery, viz. :—

- (a) A coal-cutting machine was in use.
- (b) Narrow galleries had been driven first and these were being cut out by wider workings. The explosion originated in the narrow gallery.
- (c) At the time of the explosion the ventilating current in the narrow gallery in which the explosion originated was probably strong—two days after the explosion it was measured and found to be flowing at a velocity of 315 feet per minute. In the widened galleries, however, the movement of the air was slow.
- (d) “A thin layer of small coal and dust from three-quarters to one and a half inches thick”† covered the floor of the galleries.
- (e) A “permitted” explosive was said to have been used and the maximum charge ever detonated in the mine was stated to be 10 ounces as compared with the maximum permissible charge of 26 ounces.
- (f) Apparently only one shot was fired at the time of the explosion.
- (g) The shot was not the usual kind of blown-out shot, but was rather a blown-through shot, i.e., it had blown out the end of the shot-hole into the narrow gallery above.
- (h) The explosion was not violent, but, judging from the extent of the coking and the fact that all the victims died of burns, the flame must have been fierce.

Many of the above points, we think, are important and we may find it necessary to refer to them more fully elsewhere. The explosion at Parbelia was not only the most serious that has occurred in the history of Indian mining but the most illuminating with respect to the conditions which may give rise to an ignition of coal-dust, and for that reason no aspect of the occurrence which has a bearing on the problem of the coal-dust danger should be overlooked.

11. Mr. G. N. A. Pitt, described an ignition of coal-dust which occurred at a colliery at Giridih.‡

“The ignition occurred on the surface. A wagon of coal was being emptied by opening side doors in the wagon and allowing the coal to fall out. A cloud of dust was formed which was carried by a moderately strong breeze in a direction across the line. The dust cloud was ignited and burst into flame. The cause of the ignition was said to be red-hot ashes which had fallen from the ash box of the locomotive”.

* *Notes on Coal-Dust Explosions in Indian mines.* Paper read before the Mining and Geological Institute of India at the Annual meeting on February 8th, 1924.

† *Report of the Inquiry Committee*, page 5.

‡ *Transactions of the Mining and Geological Institute of India*, Vol. III, p. 121.

12. So far as we are aware there is on record only one series of tests on the inflammability of Indian coals. These were on a small scale and the experimenter showed that coal-dust ignited by an open light in a small tin case could produce sufficient violence to blow off the lid.*

COMPARATIVE INFLAMMABILITY OF INDIAN COALS

13. The majority of Indian coals are bituminous in character. The quality of the coal obtained varies greatly in different districts. Table I gives the proximate analyses of four good quality coals mined in different districts.

TABLE I.

Proximate analysis of coals from four different districts.

	Assam. Ledo seam.	Bengal. (Raniganj Coalfield). Dishergarh seam.	Bihar and Orissa. (Jharia Coal- field). No. 15 seam.	Central Provinces. Pench Valley coal.
Ash	1·9	10·68	14·5	19·42
Moisture	1·3	2·15	1·0	2·61
Volatile matter ..	43·7	34·80	24·8	26·78
Fixed carbon ..	53·1	52·37	59·7	51·19
	100·0	100·0	100·0	100·0

From the table it will be seen that the ash and volatile contents vary considerably. The lower seams of the Barakar series in the Jharia coal-field are of a poorer quality than those near the top of the series. Table II compares No. 17 and No. 10 seams, No. 10 seam being the lower with six workable seams intervening.

TABLE II.

Proximate analysis of No. 17 and No. 10 seams, Jharia.

	No. 17 Seam.	No. 10 Seam.
Ash	12·1	18·36
Moisture	1·2	1·02
Volatile matter ..	27·3	15·61
Fixed carbon ..	59·4	65·01
	100·0	100·0

*C. H. McCale, *Transactions of the Mining and Geological Institute of India*, Vol. III, page 131.

No. 17 seam is considered coal of first class quality and No. 10 seam coal of second class quality. The differences in ash and volatile content are noteworthy. Sometimes there are marked variations in the quality of the several layers of the same seam, particularly in the ash content. Table III shows the variation in a seam in the Jharia coalfield.

TABLE III.

Variation of the quality of the coal in the same seam.

				Ash. Per cent.	Volatile matter. Per cent.	Fixed carbon. Per cent.	Moisture. Per cent.
<i>Top section.</i>							
Coal	..	..	2' 2"	20·8	22·3	55·9	1·0
Coal	..	..	7' 2"	14·5	24·5	59·9	1·1
Parting about 4-ft. thick.							
<i>Bottom section.</i>							
Coal	..	..	} 1 1/2"	42·8	17·0	39·2	1·0
Carbonaceous shale							
Coal	..	..	2' 11"	13·8	23·4	61·9	0·9
Carbonaceous shale	..		6"	34·5	16·7	28·1	0·7
Coal	..	..	3' 6"	18·6	23·3	57·3	0·8
Carbonaceous shale	..		6"	64·4	33·0	2·3	0·3
Coal	..	..	2' 4"	13·9	24·6	60·7	0·8

It will be seen, therefore, that there is not only considerable variation in the quality of the coals found in different parts of India, but that many of the seams are made up of bands differing in composition. As a result of this the dust, being made from the richer and softer parts of the seams is often of better quality than the average of the seam.

14. The two factors which are of importance in estimating the comparative inflammability of a coal are the volatile content and the ash content. The carbon content is of secondary importance for although it is probable that the violence of a coal-dust explosion depends upon the calorific value of the dust, it is equally probable that its ignitability or

inflammability is closely related not to the heat value but to the volatility of the constituents of the coal. The volatile matter and its composition are of primary importance. It has been shown that the relative inflammability of coal-dusts depends rather upon the relative ease with which inflammable gases are evolved from the dusts than upon their total volatile content.* It was found that the order of inflammability corresponded fairly closely with the percentage of the inflammable matter in the coal extractable by pyridine. The method of determination followed by the British Coal Dust Committee was to ascertain the percentage of the coal substance extracted by the solvent and then to obtain the relative ignition temperature of a sample of fine dust from the same coal. It appeared that tests of a similar nature on Indian coals might prove of value and accordingly at our request the Superintendent of the Government Test House, Alipore, agreed to carry out a series of experiments on selected coals. The results of these tests together with the proximate analyses of the same coals are tabulated in Table IV.†

TABLE IV.

Proximate analysis of Indian coals and percentages of coal substance extracted by pyridine.

No. of sample.											
	1	2	3	4	5	6	7	8	9	10	11
Moisture (percentage) ..	2.10	4.97	2.00	5.65	4.63	3.23	2.61	2.14	0.94	1.94	1.14
Proximate analysis on dried samples.											
Volatiles	34.60	36.42	34.92	36.52	36.75	42.97	27.60	27.12	23.72	24.80	15.72
Fixed carbon	55.20	50.06	51.48	51.01	53.20	56.01	52.48	63.60	68.48	68.80	65.92
Ash	10.20	13.52	13.60	12.47	10.05	1.02	19.92	9.28	7.80	6.40	18.36
Percentage of coal substance extracted by pyridine (on ash-free coal).	22.2	20.9	20.1	18.4	15.4	15.2	13.8	14.2	13.3	6.1	0.68

Samples tested—

- No. 1 Sanctoria Seam. (Bengal and Bihar and Orissa).
- No. 2 Niga Seam. (Bengal and Bihar and Orissa).
- No. 3 Dishergarh Seam. (Bengal and Bihar and Orissa).
- No. 4 Ghusick Seam. (Bengal).
- No. 5 Poulati Seam. (Bengal).
- No. 6 Tikak Top Coal Thick Seam (Assam).
- No. 7 Pench Valley Seam. (Central Provinces).
- No. 8 Jharla No. 17 seam. (Bihar and Orissa).
- No. 9 Giridih Kurbarbari Seam (Bihar and Orissa).
- No. 10 Jharla No. 15 seam. (Bihar and Orissa).
- No. 11 Jharla No. 10 Seam (Bihar and Orissa).

*British Explosions in Mines Committee, Second Report.

† Each sample was crushed from lump coal and passed through a 60 mesh sieve.

For the purpose of comparison with the results obtained by the British Committee a selection of eleven has been given in Table V.*

TABLE V.

Analysis of British coals and their relative ignition temperature.

Proximate analysis.

Number of samples.	Moisture.	Volatiles.	Fixed carbon.	Ash.	Percentage (on the ash free dry coal) extracted by pyridine.	Relative ignition temperature. °C.
238 N	1.91	32.75	60.80	4.54	38.8	995
224 N	2.11	35.70	59.99	2.20	36.2	1,015
225 N	1.53	31.41	64.29	2.77	34.7	1,025
241 N	1.96	32.85	56.88	8.31	32.3	1,035
200 N	1.80	32.58	62.79	2.83	29.2	1,045
212 N	2.40	33.25	61.76	2.59	28.7	1,065
219 N	7.31	33.18	56.43	3.08	23.1	1,080
213 N	3.49	33.84	59.38	3.29	22.1	1,090
223 N	1.30	18.62	78.83	2.25	7.0	Over 1,400
204 N	0.42	15.11	78.17	6.30	4.0	Over 1,400
221 N	1.14	17.34	77.30	4.22	3.7	Over 1,400

It will be noticed that in none of the tests on Indian coals is the percentage of pyridine extraction equal to that obtained from the first six British samples. The Indian coals 1, 2 and 3 appear to approximate to the British samples 219N and 213N. On the assumption, therefore, that the percentage extraction by pyridine is a measure of the inflammability of the dust, it would appear that the first three Indian coals in Table IV are of the same order as regards inflammability as the British coals 219 N. and 213 N. The ignition temperature of 219 N. was 1080° C. and of 213 N. 1090° C. and it is probable that the dusts of the Indian coals of Sanctoria, Niga and Dishergarh seams have an ignition temperature of somewhere in the neighbourhood of 1090° C. In Table IV the Indian coals have been arranged in the order of the percentage extractable by pyridine, and therefore on the assumption postulated they are arranged in the order of their inflammability.

*Taken from Appendix III of the *Second Report of the British Explosions in Mines Committee*. The analyses were made on dust sieved through a 240 mesh sieve.

15. In the series of explosion tests carried out in an experimental mine under the auspices of the United States of America, Bureau of Mines,* one of the most important results obtained was that the explosibility of a coal-dust varies with the ratio of volatile combustible to the total combustible matter in the coal. On this basis Table VI compares the explosibility of the Indian coals tested with the British coals in Table V and some American coals. (The last are taken from the Report on the above-mentioned tests.)

TABLE VI.

Comparison of the explosibility of the Indian coals tested with certain British and American coals.

INDIAN COALS.			BRITISH COALS.			AMERICAN COALS.		
No.	Ratio	Volatile combustibles. Total combustible matter.	No.	Ratio	Volatile combustibles. Total combustible matter.	Name of Seam	Ratio	Volatile combustibles. Total combustible matter.
I	0.38	..	238 N.	0.35	..	" No. 5 " Bed Indiana	0.49	..
2	0.42	..	224 N.	0.37	..	" No. 4 " Bed Montana.	0.45	..
3	0.40	..	225 N.	0.32	..	" No. 10 " Bed Illinois.	0.42	..
4	0.41	..	241 N.	0.36	..	Pittsburgh Bed	0.40	..
5	0.41	..	200 N.	0.34	..	" E " Bed Indiana.	0.32	..
6	0.42	..	212 N.	0.35	..	Coking Coal Bed British Columbia.	0.27	..
7	0.34	..	219 N.	0.37	..	Five Creek Bed. W. Va.	0.22	..
8	0.30	..	213 N.	0.36	..	Bockley Bed W. Va.	0.20	..
9	0.25	..	223 N.	0.19	..	Bernice Bed Pa.	0.10	..
10	0.25	..	204 N.	0.16	..	Lykas Valley Pa.	0.10	..
11	0.19	..	221 N.	0.18	..	Wyoming Valley W 2 Pa.	0.06	..

Of the American coals in Table VI the first four were found to be the most explosible and the last one, which is an anthracite coal, was found to be non-explosive by the means used in the experiments. The British

*Coal-Dust Explosion Tests in the Experimental Mines 1913 to 1918, inclusive by George S. Rice, L. M. Jones, W. L. Elgy and H. P. Greenwald.

and Indian coals shown in the table are all bituminous or semi-bituminous. From a comparison it would appear that on this basis the first six of the series of the Indian coals are about of the same degree of inflammability as numbers 224 N. and 219 N. of the British series and the Pittsburgh bed of the American coals. It should be noticed that this does not place the Indian coals in the same category as they are classified on the pyridine extraction basis. It is likely, we think, that neither criterion is reliable in itself since there are undoubtedly many other factors which influence the inflammability of a coal-dust, such as, for example, the natural ash content which is notably high in Indian coals.

TESTS OF THE INFLAMMABILITY OF INDIAN COAL-DUSTS

16. We have given a brief description of the methods of testing the inflammability of coal-dust adopted in England and the United States of America. As we have stated at the outset we could not hope to attempt experiments on a scale even approximating to that used in those countries. We considered carefully whether it would not be better to send samples of Indian coals to Eskmeals in England and have tests made there, but for various reasons, the chief of which, perhaps, was that by carrying out tests here, even though on a small scale, mining men in India, if the tests were productive of results, would have an opportunity of witnessing the experiments, we decided that we should first of all, at any rate, see what could be done in India. After careful consideration it was decided that a gallery consisting of steel tubes after the manner of the experimental gallery at Eskmeals would be more suitable for the purpose than an underground gallery in coal such as that adopted by the United States Bureau of Mines. A steel gallery, we thought, would be cheaper, more easily dusted and cleaned and it would be possible to keep the tests under closer observation than if they were conducted underground. We do not, however, rule out altogether the possibility of our being able to carry out tests in an actual mine. There are many abandoned inclines in the coalfields of Jharia and Raniganj one of which it may yet be possible to utilise for explosion tests. We propose, however, to pursue the problem as far as possible in a suitable steel tube on the surface before considering whether it would be worth while carrying out experiments underground. The site chosen for the test gallery is on the Rifle Range, about one mile to the south of Dhanbad, East Indian Railway. A brief description of the finished gallery is given in Appendix I.

17. A brief account will now be given of the preliminary experiments on the inflammability of Indian coal-dusts which have been carried out at the test station.

The first dust to be tested was that from Dishergarh seam, Parbelia Colliery. The coal was ground in a ball mill which had been installed at Parbelia Colliery after the explosion there in January 1923 in order to provide shale-dust for the mine. The coal-dust was sampled at Dhanbad and it was found that 54.2 per cent. passed through a sieve having 150 meshes* to the lineal inch.

*No smaller mesh was available in India at the time.

Tests on Dishergarh seam

A proximate analysis of Dishergarh seam at Parbelia Colliery is as follows :—

Ash	..	..	..	10.98 per cent.
Moisture	..	..	..	1.48 per cent.
Volatiles	..	..	..	34.87 per cent.
Fixed carbon	..	..	..	52.67 per cent.
				100.00 per cent.

Test No. 1.—Date 22nd November 1923.

Length of tubes, 113 feet, consisting of 30 feet of tubes, 4 feet diameter, and 83 feet of boiler flues, 3 feet diameter, with cross flues at intervals. The dust was uniformly spread on the floor over the whole length of the tube to the amount of about 60 lbs. At the 4 feet diameter end of the tube a few wooden shelves were fixed, and these were also loaded with dust. A charge consisting of two cartridges of gelignite (about 4 ounces) was placed on a shelf about 6 feet from the end. Both ends of the tube were open. The charge was fired electrically.

Result.—An ignition.—The flame emerged at the wide end of the tube and extended about 10 feet horizontally and vertically beyond the tube. There was no evidence that the flame travelled through the tube to the narrow end although smoke and dust were emitted there. The total length of the flame was about 16 feet.

Test No. 2.—Same date as Test No. 1.

Same conditions as in test No. 1. Charge increased to 4 cartridges of gelignite. Position of charge—on a shelf about 6 feet from the large end of the tube.

Result.—An ignition.—The flame extended outside the tube about 15 feet horizontally and 15 feet vertically. Length of flame, 21 feet. Apparently the flame did not travel in the other direction.

Test No. 3.—Date 12th December 1923.

Two additional lengths of tubing, each 26 feet long and $3\frac{1}{2}$ feet diameter, had been obtained, and these were placed in line with and butted against the 4 feet tube, but were not joined to the others. The total length of the tubes was now 165 feet. A hand-hole was cut in one of the boiler flues at a point 100 feet from the end of the $3\frac{1}{2}$ feet diameter tubes. Dust was distributed at the rate of about $\frac{1}{2}$ lb. per foot run from the end of the $3\frac{1}{2}$ feet tube to a point about 3 feet beyond the hand-hole. The rest of the tube was not dusted. Four cartridges of gelignite were inserted through the hand-hole and placed on a shelf.

Result.—Probable ignition.—There was no visible flame but smoke emerged from both ends of the tube and continued to be emitted for about ten minutes. There had obviously been burning. The tube was so hot at a distance of about 25 feet from the position of the charge that the hand could not be held on it. There was considerable coking in the tube about 25 feet from the position of the charge.

Test No. 4.—Same date as Test No. 3.

Same conditions as in test No. 3. Strips of paper soaked in kerosene oil were hung at intervals to give an indication of the passage of the flame. (This method is admittedly crude and was only tried once.)

Result.—Probable ignition.—No flame was observed at either end of the tube but the paper strips were burnt up to a point about 40 feet from the position of the charge.

Test No. 5.—Date 22nd January 1924.

After the above tests it was decided to try gelignite on the floor of the tube instead of on a shelf. Nine feet of the $3\frac{1}{2}$ feet tube was coal dusted and a charge of two cartridges placed amongst the dust on the floor of the tube, and fired. No shelves were used.

Result—An ignition.—The flame extended 15 feet outside the tube. Length of flame 24 feet.*

Test No. 6.—Same date as Test No. 5.

Repetition of test No. 5.

Result.—An ignition.—The flame extended to from 15 feet to 20 feet outside the tube. Total length of flame between 24 and 29 feet in one direction.

Test No. 7.—Same date as Test No. 6..

Same conditions as in test No. 6 but charge placed 13 feet from the end of the tube.

Result.—An ignition.—The flame extended outside the tube about 15 feet. Length of flame, 28 feet.

Test No. 8.—Date 25th January 1924.

Same conditions as in Test No. 7. Distance of charge from the end of the tube, 20 feet.

Result.—No ignition.—No flame and little smoke. The reason for this failure is not clear. At first the charge did not explode and it was only at the third attempt that it went off and then, judging from the report, feebly. It was thought that the detonator may have been defective causing imperfect explosion of the charge.

Test No. 9.—Same date as Test No. 8.

Same conditions as in test No. 8. Distance of charge from end of tube, 17 feet.

Result.—An ignition.—The flame emerged from the end of the tube and extended outside the tube for about 15 feet. Length of flame, about 32 feet.

Test No. 10.—Same date as Test No. 9.

Same conditions as in previous tests. Charge placed at a point 28 feet from the end of the tube.

*To ascertain the amount of flame from an untamped charge of gelignite two cartridges of gelignite were fired on a clean steel plate in the open. The flame was hardly noticeable.

Result.—*A feeble explosion.*—The flame travelled rapidly, shot out of the end of the tube about 15 feet and the force was such as to shoot coal-dust out of the tube in a straight line for a distance of about 100 feet. Length of flame, about 43 feet.

Test No. 11.—Date same as Test No. 10.

Same conditions as before. Length of tube dusted, 60 feet. Charge of two cartridges of gelignite placed on the floor of the tube 58 feet from the end of the 3½ feet tube.

Result.—*A feeble explosion.*—The flame travelled rapidly and shot out of the end of the tube about 6 feet, scattering dust in a straight line about 100 feet ahead. Length of flame, 64 feet.

It will be noticed that the results of the last two tests have been recorded as feeble explosions. It was clear to the observers that tests Nos. 10 and 11 were different from any of the other tests. In the visible ignitions, *e.g.*, tests Nos. 1, 2, 5, 6, 7 and 9 the flame emerged from the tube quietly and, outside the tube, spread upwards as well as horizontally, but in tests Nos. 10 and 11 the flame literally “shot” out of the tube. That is, in the case of the “ignitions” the inflammability was quiet and slow, but in tests Nos. 10 and 11 it was obviously so rapid as to partake of the nature of a mild explosion. There was no obstruction in the tube, not even wooden shelves, or greater violence might have been attained. Moreover in test No. 10 the flame had to cross a gap of about one inch between the ends of two, 3½ feet diameter, tubes, where they were butted together, and in test No. 11 the flame had to cross two such openings. In each case the flame “overflowed” at the openings, but apart from that propagation was apparently not hindered in the slightest.

Summary of preliminary results on the Dishergarh seam.

<i>No. of Test.</i>	<i>Result.</i>	<i>Length of flame.</i>
1	Ignition	16 feet.
2	Ignition	21 feet.
3	Probable ignition	flame not seen.
4	Probable ignition	flame not seen.
5	Ignition	21 feet.
6	Ignition	24 to 29 feet.
7	Ignition	28 feet.
8	No ignition	..
9	Ignition	32 feet.
10	Feeble explosion	43 feet
11	Feeble explosion	64 feet.

It should be noted that in each ignition or explosion the flame would probably extend a few feet on the other side of the charge, although that could not be seen. The actual lengths of flames would, therefore, be a few feet greater than those recorded.

Tests on No. 15 seam, Jharia.

18. Preliminary tests on dust from No. 15 seam Jharia were carried out in a similar way to those on Dishergarh seam. A proximate analysis of No. 15 seam is as follows :—

Ash	..	..	..	..	14.24
Moisture	..	..	..	..	1.15
Volatiles	..	..	..	..	23.05
Fixed carbon	..	..	..	..	61.56
					100.00

Test No. 12.—Date 2nd February 1924.

A charge of two cartridges of gelignite was laid on the floor of the tube, 18 feet from the end.

Result.—An ignition.—The flame extended 6 feet beyond the end of the tube. Length of flame, 24 feet.

Test No. 13.—Same date as Test No. 12.

Same conditions as above.

Result.—No ignition.—Only local flame produced.

Test No. 14.—Same date as Test No. 13.

Same conditions as above.

Result.—No ignition.—Only local flame produced.

Test No. 15.—Same date as Test No. 14.

Same conditions as above.

Result.—An ignition.—Length of flame, 25 feet.

Tests 12 to 15 were carried out on dust ground artificially in a hand-grinding machine ; 81.4 per cent. of the dust passed through a 150 mesh sieve.

Test No. 16.—Date 6th February 1924.

Same conditions as in Tests Nos. 12 to 15.

Result.—An ignition.—Length of flame, 25 feet.

Tests Nos. 17, 18 and 19.—Same date as Test No. 16.

Results.—No ignitions.—Only local flame produced.

Tests 16 to 19 were carried out on dust collected at the screening plant of a colliery in the Jharia coalfield. On screening a sample of the dust it was found that only 16.7 per cent. passed through a 150 mesh sieve. It is probable that the finest of the dust was used in the first test.

Test No. 20.—Date 5th March 1924.

Same conditions as in previous tests, but a charge of three cartridges of gelignite was used.

Result.—An ignition.—Length of flame, 30 feet.

Tests Nos. 21 and 22.—Same date as Test No. 20.

Charge of two cartridges of gelignite used.

Results.—No ignitions.—Only local flame.

The dust used in tests 20 to 22 was ground in a motor-driven Hardy multiple grinder : 66.7 per cent. of the dust passed through a 150 mesh sieve.

Summary of results on No. 15 seam, Jharia.

<i>No. of test.</i>	<i>Result.</i>	<i>Length of flame.</i>
12	Ignition	24 feet.
13	No ignition	..
14	No ignition	..
15	Ignition	25 feet.
16	Ignition	25 feet.
17	No ignition	..
18	No ignition	..
19	No ignition	..
20	Ignition	30 feet.
21	No ignition	..
22	No ignition	..

It would appear from these tests that No. 15 seam Jharia is more difficult to ignite than Dishergarh seam. The tests are not, however, conclusive and a more thorough investigation will be made.

Tests with the dust of Sanctoria seam

18. Proximate analysis of Sanctoria seam.—

Ash	..	..	..	10.18
Moisture	..	..	..	2.06
Volatiles	..	..	..	33.34
Fixed carbon	..	..	..	54.42
				100.00

The dust used in the tests of this seam was ground in a motor-driven Hadfield multiple grinder.

The screen analysis showed that 72 per cent. passed through the 120 mesh sieve. The 150 mesh sieve had become damaged and could not be used.

Test No. 23.—Date 22nd March 1924.

This test was made near the end of a 4 feet 6 inches diameter tube. The dust was strewn on the floor at the rate of about $\frac{1}{2}$ lb. per lineal foot for a distance of 14 feet from the end. Two cartridges were laid in the dust on the floor of the gallery, 11 feet from the end. The charge was fired electrically.

Result.—An ignition.—The flame extended about 10 feet out of the tube. Length of flame from point of ignition, 21 feet.

Test No. 24.—Same date as Test No. 23.

Same conditions as in test No. 23. Charge placed on the floor 20 feet from the end of the tube.

Result.—An ignition.—The flame extended about 8 feet out of the tube. Length of flame, about 28 feet.

Test No. 25.—Same date as Test No. 24.

In this test 80 feet of gallery (65 feet of the $4\frac{1}{2}$ feet diameter tubing and 15 feet of the $3\frac{1}{2}$ feet tubing) was strewn with dust. There were four joints in this length. These were held by bolts but were not tight. The charge of two cartridges of gelignite was placed on the floor, at 78 feet from the end.

Result.—An ignition with some propagation.—The flame was not observed at the end of the tube, but was seen to 'overflow' at the open joints up to a point 40 feet from the charge. There was coking up to the end of the tube, and for about ten minutes after the ignition, smoke and distilled gases emerged from the end of the tube in dense volumes. The length of $4\frac{1}{2}$ feet tube nearest the charge—distance from charge about 15 feet and length of the $4\frac{1}{2}$ feet tube 22 feet—was so hot that during contraction on cooling loud cracking noises were emitted. Length of flame at least 40 feet.

Summary of results of preliminary tests on Sanctoria Seam.

<i>No. of test.</i>	<i>Result.</i>	<i>Length of flame.</i>
23	An ignition	21 feet.
24	An ignition	28 feet.
25	An ignition	At least 40 feet.

20. It will be observed that the dusts used in the foregoing tests were not nearly so fine as those used at Eskmeals in England by the British Explosions in Mines Committee or in the United States at the Experimental Mine, most of which tests were carried out on dust of which from 80 to 90 per cent. passed through a 200 mesh sieve. So far we have not been able to grind the dust to that degree of fineness. Unquestionably if the dust had been pulverised more finely, better ignitions would have been obtained. We hope to improve the grinding. As has been indicated these tests are of the nature of preliminary experiments. Our intention was eventually to adopt what has now become the standard method in such tests, namely, firing from a cannon.

Experiments with gunpowder

21. Although it was found convenient to use gelignite in the preliminary tests, it appeared to be difficult to get propagation of flame throughout the full length of the experimental gallery by means of that explosive. In tests Nos. 3 and 4, for example, the flame failed to propagate throughout the tube. Moreover, gunpowder is generally used for blasting coal and for that reason alone we considered it essential that tests should be made with it. The tests now to be described were made with locally manufactured gunpowder. The gunpowder was poured loosely into the bore of the cannon, about $1\frac{1}{2}$ lb. of the explosive being used in each experiment. The cannon was placed on the floor of the tube at the point indicated in the sketch in Appendix I in which the gallery, cannon, method of firing, etc., are described. The cannon tests were done in the completed gallery.

Test No. 26.—Date 1st April 1924.

The cannon was charged with about $1\frac{1}{2}$ lbs. of country gunpowder and stemmed with 8 inches of clay. About 65 lbs. of dust of Sanctoria seam was strewn fairly uniformly along the floor of the gallery from the end of the $4\frac{1}{2}$ feet diameter tube to the firing point, *i.e.*, about $\frac{1}{2}$ lb. per foot run. No shelves were used. The fineness of the dust was the same as in the tests Nos. 23, 24 and 25. The tube was open at the large end and closed by a wooden door bolted to the tube at the other end. The cannon was laid on the floor. The charge was fired electrically.

*Result.—Ignition and propagation (i.e., explosion).—*The flame was seen to emerge at a joint of the tube 80 feet from the position of the cannon, but did not appear at the end of the tube. The wooden door was blown off, broken and the parts thrown a distance of about 40 feet. After the ignition dense fumes continued to emerge from the tube for a period of about a quarter of an hour. One of the tubes, at a point about 90 feet from the firing point, appeared to have been subjected to great stress, as it had been bulged and distorted.

Test No. 27.—Date 9th April 1924.

Same conditions in every respect as in test No. 26, except that the stemming consisted of 4 inches of coal-dust next the charge and 4 inches of clay.

Result.—Ignition and propagation of flame throughout the tube.

The flame passed right through the tube, emerged at the large end and extended about 35 feet beyond the tube. Total length of flame, 175 feet, in one direction. The wooden door at the other end was again blown off. The propagation was comparatively slow. One of the tubes, 40 feet from the large end, had been subjected to great stress and was distorted into a triangular shape over a length of about 20 feet and was broken at one point.

The lack of great violence is explained by the facts that there were no obstructions in the tube, that the joints were not perfectly tight and that the wooden door at the near end acted as a safety valve for the pressure. The length of the tube, too, is probably insufficient to enable great violence to be attained. In this test safety matches fixed at intervals in the tube were used as flame indicators.

Demonstration tests

22. The following tests were made in the presence of a large gathering of members of the Mining and Geological Institute of India and the

Colliery Managers Association. The date of the tests was 11th April 1924. The demonstration was given in darkness.

Test No. 28.—Cannon test.

Same conditions in every respect as in test No. 27, Sanctoria seam. The flame was seen to emerge at a joint about 100 feet from the firing point. A few of the observers thought the flame reached the end of the tube, but this was uncertain.

Test No. 29.—Ignition test.

This test was done in a similar way to some of the earlier experiments already recorded. About 25 feet of gallery at the large end of the tube was dusted and a charge of two cartridges of gelignite fired on the floor of the gallery at a point about 20 feet from the end. The dust used was that from No. 17 seam Jharia.

A striking ignition was obtained, the flame emerging from the end of the tube and rising and spreading to a height and width variously estimated at 25 feet to 30 feet.

Test No. 30.—Ignition test.

Same conditions in every respect as in test No. 29, but dust from Dishergarh seam. The flame in this test rose about 20 feet in height outside the tube, but was not quite so large in volume nor did the combustion appear to be so complete as with No. 17 seam Jharia in test No. 29. It is probable that in test No. 29 the ignition was affected to some extent by the dust remaining from test No. 28. The tube had been fairly well cleared of dust by the flame and force of the explosion in test No. 28 but was not swept clear before being dusted with No. 17 seam dust. After test No. 29 the tubes were swept clean before Dishergarh dust was laid.

23. The experiments recorded above, although insufficient to enable us to form definite conclusions as to the relative inflammability of the seams tested, serve to show that ignitions and explosions can readily be obtained. So far no attempt has been made to measure pressures or destructive effects. We hope, however, to improve on the present arrangements. In particular we wish to point out that many additional experiments will have to be carried out before the investigation can be considered complete.

CONDITIONS AS REGARDS COAL-DUST IN INDIAN MINES

24. We have deemed it advisable to ascertain, by actual sampling and sieving and by observation, to what extent Indian mines harbour coal-dust. The conditions in Indian mines are not the same as those in British mines. The seams are thicker, there is little or no fire-clay holing or undercutting and the method of working almost universally practised is bord and pillar with galleries from 10 feet to 18 feet wide and often as high as 25 feet to 30 feet. As a rule a considerable extent of whole working is done before 'broken' work is attempted. The galleries as a rule are fairly straight but often irregular. The great size of the galleries is a feature to which we shall again have occasion to refer. The bulk of the coal is got by hand-picking and blasting from the solid, although machine mining is now developing very rapidly. The character and fineness of the dusts found in working galleries depends to some extent on the hardness or softness of the seams. Some seams are of a softer nature and more uniform in quality than others and it is to be expected that in such seams

the dust found will be of a finer consistency and greater in quantity than in the harder seams. For example, samples were taken from the floors of two hand-cut galleries, one in a seam of a hard nature and the other in a seam of a friable nature and the percentage of the sample which passed through a 150 mesh sieve in the case of the soft seam was nearly three times as much as that in the case of the hard seam.

The following analysis illustrates the conditions in a typical hand-cut gallery in an Indian mine.

TABLE VII.*

Size.	Weight.		Percentage of total sample.	Quantity per 100 cubic feet of roadway.	
	lb.	Oz.		lb.	Oz.
Passed through 150 mesh sieve ..	3	$\frac{5}{16}$	11.76	1	7
Between 120 and 150 mesh sieve ..	0	$2\frac{1}{2}$	0.60	0	1
Between 80 and 120 mesh sieve ..	2	$1\frac{5}{16}$	8.03	0	$12\frac{3}{4}$
Between 60 and 80 mesh sieve ..	1	$5\frac{1}{8}$	5.26	0	$8\frac{1}{4}$
Between 30 and 60 mesh sieve ..	5	$12\frac{3}{8}$	22.32	2	$3\frac{3}{8}$
Above 30 mesh sieve ..	13	$7\frac{1}{8}$	52.03		

The sample was collected from a length of gallery of 10 feet, the width and height of the gallery being 5 feet 6 inches and 4 feet 9 inches, respectively. The gallery had first been driven narrow and was being widened out and heightened. The amount of dust on the surfaces of the gallery was not excessive and similar conditions may be seen in any Indian mine where the conditions are dry. It will be seen that nearly 50 per cent. of the sample passed through a sieve having 900 meshes to the square inch, *i.e.*, 30 meshes to the lineal inch, and 11.76 per cent. passed through a sieve having 22,500 meshes to the square inch, *i.e.*, 150 meshes to the lineal inch. Dust which will pass through 150 mesh sieve must be considered very fine dust and in this case there was one pound of such dust to every 90 cubic feet of air space considerably more than that required for an explosion.

25. In their report on the disaster at Parbelia Colliery on the 4th January 1923, the Committee of Inquiry drew attention to the fact that "owing to the introduction of coal-cutting machinery which produced dust in greater quantity and of finer consistency than the old system of hand cutting, the danger of explosions from coal-dust had greatly increased in Indian mines". This opinion presumably was suggested by the fact that at the time of the explosion and, for a short time before it, a coal-cutting machine had been in use in Parbelia Colliery. We have carried out some investigations on the point and they go to show that for a given quantity of coal produced the amount of fine dust is slightly greater in the case of hand-cut gallery than in a machine-cut gallery. If, however, the comparison is made on a time basis, the quantity of fine dust

*Taken from *Notes on the Coal Dust Danger in Indian mines* by D. Penman.

produced in a machine-cut gallery is considerably greater than the quantity produced in a hand-picked place. This is due to the fact that the rate of production of coal in a machine-cut gallery is from three to five times that in hand-picking. Another point worthy of consideration is that there is, as a rule, more stir in a machine-cut place than in a hand-picked place, both during cutting and loading and consequently there is generally more dust in suspension in the air. We have also made tests on the fineness of the cuttings produced by different types of coal-cutting machines and have found that certain types appear to produce finer dust than others. Every type of machine, however, produces in a single under-cut sufficient dust capable of passing through a sieve with 32,400 meshes to the square inch to render explosive considerably more than a volume of air equal to the volume of the coal got from the under-cut. For example, in one test the quantity of the cuttings from a single under-cut, 5 feet deep and 14 feet wide, which passed through 180 mesh sieve* (32,400 meshes to the square inch) was 42.7 lb. The height of the gallery blasted down was about 6 feet. This quantity of dust was sufficient to render the air in a length of gallery of 76 feet explosive. In addition there was a large quantity of dust in the cuttings which passed through sieves between 30 and 180 meshes to the lineal inch which cannot be said to be incapable of taking part in an explosion. There is also the dust from the drilling of shot-holes, the shattering effect of blasting, the breaking up of loosened coal, loading, etc. It will be clear, therefore, that the quantity of fine coal-dust produced in a machine-cut gallery is more than sufficient to provide the necessary fuel for an explosion.

26. Many of the haulage roads in Indian mines are dry and dusty. The dust found there is much finer than that found in the working places. Table VIII shows the results of three different samples from the sides of haulage roads.

TABLE VIII.

	Sample (A) collected from the side of a haulage road about 2 ft. from the floor.	Sample (B) collected from the side of a haulage road about 4 ft. from the floor.	Sample (C) collected from the side of a haulage road about 3 ft. from the floor.
	Per cent.	Per cent.	Per cent.
Passed through 150 mesh ..	15.7	35.90	17.85
Between 120 and 150 mesh ..	4.2	0.22	1.18
Between 80 and 120 mesh ..	4.2	15.38	11.97
Between 60 and 80 mesh ..	10.2	11.34	6.57
Between 30 and 60 mesh ..	14.2	19.23	32.86
Larger than 30 mesh ..	51.5	17.93	29.57
	100.0	100.00	100.00

*A 180 mesh sieve had been obtained when this test was carried out.

It will be seen that in each case the dust is much finer than that found in the working gallery in the analysis in Table VII. The above figures indicate that in many Indian mines, there is sufficient fine coal-dust to initiate and feed the flame of an explosion. We shall return to this aspect of the problem in a subsequent report.

REMOVAL OF COAL DUST FROM THE MINES

27. From our knowledge of the conditions in Indian mines we consider that there is considerable room for improvement in the removal of slack and dust from the workings. In some cases the state of the market affects the amount of slack left in the mine but in many instances much small coal and dust is allowed to accumulate in travelling and haulage roads simply through neglect. For example, in one mine the dusty state of the haulage roads led the management to give orders for the slack to be cleaned up. Over 60 tons of slack and dust were said to have been removed. The slack was dry and was proved by screen analysis to contain more than sufficient fine dust to initiate or propagate an explosion. Tests at the experimental test station at Dhanbad have proved that fine dust from this seam is highly explosive. The systematic removal of the coal dust from the mine is a fundamental precaution that should be taken in every mine and we strongly recommend the adoption of this simple precaution as far as practicable. In the case of the cuttings from a coal-cutting machine we would suggest that they should be thoroughly soaked with water before being disturbed and then loaded into tubs before the under-cut coal is blown down. By doing so a great deal would be done to reduce the amount of fine dust raised into the air and deposited on the floor and sides of the galleries during the removal of the dust in a dry condition or during blasting.

SHOT-FIRING

28. Shot-firing is a frequent cause of ignition of inflammable gas and coal-dust. Many of the most disastrous explosions, which have occurred in England and elsewhere, have been initiated by the flame from explosives. The explosion at Parbelia Colliery was caused by the flame discharged from a badly placed shot. This being the case we consider it essential that the explosives to be used in a dry and dusty mine and the precautions to be taken in their use should receive full and careful consideration.

The following table shows the quantity of explosives used in coal mines in British India during the period 1918-22.

	1918.	1919.	1920.	1921.	1922.
	lb.	lb.	lb.	lb.	lb.
Gunpowder . .	404,289	424,022	517,505	786,689	1,267,377
High explosive	154,192	228,365	207,604	246,701	216,090

It will be seen that there has been a large increase in the quantity of gunpowder used in recent years. The increase is most notable in the mines in the provinces of Bihar and Orissa, Bengal and the Central Provinces, in each of which the quantity of gunpowder used in 1922 was approximately three times the quantity used in 1918. In coal mines in Bihar and Orissa 783,716 lb. of gunpowder were used in 1922, as compared with 234,633 lb. in 1918. This large increase in the use of explosives has not been accompanied by a larger output, for the output in 1922 was less than the output in 1919. It points simply to a change of method from hand-picking to blasting either from the solid coal or after the coal has been machine cut. Since shot-firing is the most prolific cause of explosions, the increasing use of explosives must necessarily accentuate the hazard of firedamp and coal-dust explosions.

29. Where serious danger is apprehended the safest course is undoubtedly to avoid the use of explosives altogether. Shot-firing is, however, an economic necessity in coal mining in India and with the rapid development of machine coal cutting, the quantity of explosives used is likely to continue to increase. For these reasons, while advocating that in mines where there is likely to be a danger from fire-damp or coal-dust shot-firing should be reduced to a minimum, we do not think that the circumstances at present warrant any further recommendation in the direction of the elimination of the use of explosives. The new draft regulations under the Indian Mines Act, 1923, governing the use of explosives underground, provide sufficient safeguards we think for general application. It may, however, afterwards be necessary to recommend additional precautions in the use of explosives in certain mines or groups of mines, but that we are not yet in a position to say.

30. Regulations regarding procedure are apt to fail in their purpose, however, unless they are intelligently and scrupulously carried out in practice, and we have some remarks to make in this connection. From the point of view of the danger of an explosion of coal-dust the regulation requiring the use of clay or other non-inflammable substance for tamping or stemming is of great importance. Many instances occur, however, of small coal and coal-dust being used for stemming. Such a practice cannot be too strongly condemned. A shot stemmed with coal-dust is much more likely to initiate an explosion of coal-dust than one stemmed with clay or other non-combustible material. The shot, as it is discharged, is in intimate contact with a highly inflammable material and the flame from the shot is likely to be greatly extended by the coal-dust tamping, especially if the shot is blown-out. A recent explosion* of coal-dust at the Plean Colliery, Stirlingshire, Scotland, was initiated by a blown-out shot which is supposed to have been stemmed with coal-dust. As a rule the shot-firer himself is to blame for this infringement of rules. The practice in many mines is for the shot-firer or his coolie assistant to take sufficient clay into the mine with him for the day's work. The supply is sometimes forgotten or has not been brought through carelessness or laziness. But the shots have to be fired and so the material ready to hand, namely, small coal, is used. In some mines, however, a supply of clay is placed at convenient places in the mine, and the shot-firer is, therefore, put to little trouble to obtain it and has no excuse for not obtaining it. The responsibility for seeing that a sufficient supply of clay is constantly available for the use

* Report on explosion at Plean Colliery, Mines Department, Great Britain, 1922.

of the shot-firers is put on the overmen or sirdars in charge of the several districts. We are strongly of the opinion that this practice should be adopted wherever underground shot-firing is carried on and we recommend that a regulation should be made requiring the provision of a supply of clay tamping in convenient places.

31. In dry and dusty surroundings a danger may arise from the simultaneous lighting or firing of shots. If the shots are fired electrically they will discharge simultaneously ; if they are fired by the ordinary safety fuse there may be intervals between the discharges. A number of shots discharging simultaneously may and probably will produce greater concussion and more flame than a single shot. It is conceivable, therefore, that the discharge of a number of shots simultaneously might initiate an explosion which might have been prevented if the shots had been fired one at a time with a sufficiently long interval between each shot. A number of shots lighted simultaneously but discharging successively may produce conditions still more dangerous than several shots fired together. A number of coal-dust explosions—notably that at Altofts Colliery in Yorkshire (England) in 1885—have resulted from the firing of several shots in this way. The first shot or shots raised the fine coal-dust in the vicinity in a cloud and the final shot ignited the dust cloud causing an explosion which afterwards extended throughout the mine. The correct placing of shot-holes is of the utmost importance and in places where there is a risk of an ignition of coal-dust great care should be taken by the management of the mine to impress upon all shot-firers the necessity of so placing and proportioning the charge that it will do the work which is intended.

32. In many mines blasting from the solid is the common practice. As a result blown-out shots occur quite frequently. The view has been put forward that the fact that many thousands of shots, including undoubtedly occasional blown-out shots, have been fired in a particular mine without an ignition having occurred is proof that the danger of coal-dust explosion in that mine is non-existent. This fact cannot be ignored and it may be possible when we have fuller information on the subject to adduce reasons for the apparent immunity from the risk of coal-dust explosions.

33. We agree to the proposal in the new draft regulations that only 'permitted' explosives should be used in any ventilating district of a mine in which inflammable gas has been reported. While it is true that no explosive has yet been invented which would be absolutely safe to use in a dry and dusty mine, it is equally true that a 'permitted' explosive which has been subjected to severe tests in the presence of explosive atmospheres of firedamp and coal-dust is much less likely to bring about an ignition of firedamp or coal-dust than one which has not passed such tests. We would go further and suggest that the regulation should also be made applicable to any mine or seam in which in the opinion of the management or the Chief Inspector of Mines a danger of an explosion of coal-dust is apprehended. We also suggest that where 'permitted' explosives are used in accordance with the regulations :

(a) all shots shall be fired simultaneously by electrical means ;

(b) the aggregate charge in any number of shots fired simultaneously shall not exceed that in which in the opinion of the explosive used ;

- (c) before a shot is fired the shot-firer shall examine with a locked safety lamp or other apparatus approved for the purpose by the Chief Inspector of Mines the place where the shot is to be fired and all contiguous accessible places within a radius of twenty yards and if inflammable gas is found shall remove it, or if the place is dry and dusty shall render the dust harmless within a radius of ten yards of the place where the shot is to be fired ;
- (d) no shot shall be fired in coal which has not been undercut, overcut or side cut, and that the length of the shot hole shall be at least 6 inches less than the length of the cut.

CONDITIONS IN SEAMS WHICH GIVE OFF FIRE-DAMP

34. In some Indian mines fire-damp is given off in greater or lesser quantities. The number of mines in which safety lamps are used, and the number of mines in which mechanical ventilators are used are given in Table IX.

TABLE IX.

Province.	Number of mines in which safety lamps are used by the miners.	Number of safety lamp mines which are mechanically ventilated.
Bengal	21	9
Bihar and Orissa	14	8
Assam	5	5
Central Provinces	1	1
Punjab	0	0
Baluchistan	6	1

In addition there is a number of mines in which safety lamps are used for examination purposes. It will be seen that the largest number of gassy mines is situated in Bengal. As a rule there are several accidents each year due to ignitions of fire-damp. Many of these accidents would have been prevented by more careful examinations for the presence of inflammable gas, and by better ventilation. Seams in which fire-damp is given off are just as frequently dry and dusty as mines in which no fire-damp is found. Moreover the coal is generally richer in volatile matter than seams which are free from fire-damp, *e.g.*, compare the Dishergarh, Sanctoria, Niga and Ghusick seams, all of which give off fire-damp, with Nos. 17 and 15 the best seams of the Jharia coal-field which are practically free from fire-damp. (Table IV). Add to this the ever-present hazard of accumulations of inflammable gas, and it will be readily acknowledged that the risk of a coal-dust explosion is greater in seams which give off fire-damp than in seams which are non-fiery. An excursion through the records of coal-dust explosions in any of the great coal-producing countries will show that a large proportion of them have occurred in seams which

gave off fire-damp, and that in many of these the explosion of coal-dust was preceded or initiated by an ignition of fire-damp. In such cases the ignition of fire-damp has been likened to the detonator in a charge of high explosive, the charge itself being coal-dust. The simile is hardly over-drawn for it is highly probable that but for the pioneering ignition of fire-damp many of these explosions would never have occurred. Further, even a very small percentage of inflammable gas in the general body of the air in dry and dusty places increases the likelihood of an ignition of coal-dust. It is clear, therefore, that, in India as elsewhere, a dry, dusty mine in which fire-damp is found is a more dangerous proposition than a similar mine in which fire-damp is unknown.

35. Out of 35 collieries in the Raniganj and Jharia coalfields working seams evolving inflammable gas only 17 are provided with mechanical ventilation. This, we think, is a matter which requires attention. Natural ventilation is always irregular and uncertain. The strength of the ventilating current produced depends upon a variety of circumstances over which the management of the mine have little or no control. The season of the year, the number of openings into the mine, the direction and strength of the wind, the natural heat of the mine workings, night and day, traffic movements, etc., all have an influence not only on the amount of ventilation in the mine but on the direction in which the air flows. As a result the ventilation in a mine unprovided with a ventilating device which is independent of atmospheric conditions is unreliable and, as a rule, inconstant. At one period the air-current may be strong and adequate, at another it may be nearly stagnant, and at yet another it may be flowing strongly in the opposite direction. In a seam which gives off fire-damp such a condition of things is, to put it tersely, unsafe. The provision of a ventilating current constant in direction and adequate in amount is essential in a gassy mine, and such a current cannot be obtained by natural means alone. We would suggest, therefore, that every mine in which safety lamps are required to be used or in which regular inspections have to be made for inflammable gas, should be provided with an artificial means of ventilation, preferably a mechanical ventilator.

36. The provision of an adequate and reliable air supply is in itself, however, insufficient unless the air is properly coursed in the working places. All 'dead ends' should be bratticed or partitioned off in some way so as to divide the gallery longitudinally into two portions. It is only by such means that a gallery in a seam which gives off inflammable gas or where danger from gas is apprehended can be adequately ventilated.

37. For the purpose of development, main galleries are sometimes driven considerably ahead of the general position of the workings. Where this is necessary, the advance galleries should be driven in pairs and connected together as soon as possible after they have progressed a distance equal to the length of the side of a pillar. It is common practice to drive narrow development galleries ahead of the main galleries. The size of such narrow galleries is about 4 feet to 6 feet high and 2 feet to 3 feet wide. They are sometimes driven in the middle of the main drivage, and sometimes at one side. Miners of a certain class like the work of driving these narrow galleries, as they are paid for the distance cut and are thus, while so engaged, not so subject to the delays consequent on imperfect haulage arrangements

as the men who are dependent on output alone. The provision of narrow galleries in advance of the main drivings facilitates the cutting of the coal in the widening operations as the miner has then an 'open end.' It also permit a large number of miners to be employed in each gallery. The system just described is in our opinion an undesirable one, and in a seam which gives off fire-damp gives rise to a serious danger. Advance galleries naturally 'bleed' the coal, that is to say, gas is more freely given off from the freshly cut coal than elsewhere. In a gassy seam, therefore, fire-damp is more likely to be met with in these narrow galleries than in the wider drivages following. Narrow galleries are, however, difficult and indeed impossible to ventilate. As a rule air in them is practically stagnant and if gas is being given off, accumulations are bound to occur. Again, in a gassy seam in which fire-damp is given off more or less generally from the freshly cut coal an explosive percentage is more quickly attained in a small gallery than in a large one, for the surface exposed varies directly as the length of one side of the perimeter, whereas the volume of air in the airway varies as the square of the length of the side. We are of the opinion that in seams in which inflammable gas has been found during the previous twelve months no narrow advance gallery should be driven more than six feet ahead of the widened gallery, and that in every gallery the ventilating current should be conducted as near to the working face as is practicable.

38. We view with satisfaction the regulations regarding the examination and certification of underground sirdars. The official who examines the working of the mine is one of the most important officials on a colliery. We are convinced that increased confidence and security will ensue from a knowledge that the officials who are entrusted with the sirdar's duties have shown their competency in examination.

SUMMARY.

39. (a) A brief review of the evidence of the explosibility of coal-dust in air is given, and a comparison is made between Indian and British and American coals as regards their inflammability. (Paragraphs 2 to 15).

(b) A series of preliminary tests of the inflammability of Indian coal-dusts is described. (Paragraphs 16 to 23).

(c) The conditions with respect to coal-dust in Indian mines are discussed and suggestions made regarding its removal. (Paragraphs 24 to 27).

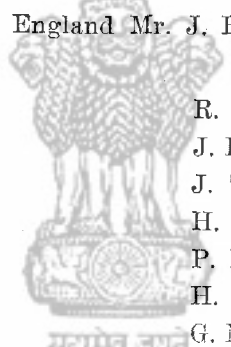
(d) An outline is given of some of the aspects of shot-firing in Indian mines from the point of view of the danger from coal-dust, and recommendations are made regarding the provision of clay for tamping purposes at convenient points in the mine, and the use of "permitted" explosives. (Paragraphs 28 to 33).

(e) Attention is directed to the necessity for improvement in the ventilation of mines in which fire-damp is found and suggestions made to that end. (Paragraphs 34 to 38)

40. We are greatly indebted to the following gentlemen for valuable assistance in the provision and erection of the test gallery and the plant attached to it :—

Messrs. D. A. Anderson, J. B. Wardlaw and S. McMurtrie of Messrs. Andrew Yule and Company, Limited ; Mr. R. G. M. Bathgate of the East Indian Coal Company, Limited ; Messrs. F. L. Cork and W. D. Robb of the Equitable Coal Company, Limited ; Mr. J. Murray of the Raniganj Coal Association, Limited ; Mr. R. Barrowman of the Standard Coal Company, Limited ; Mr. D. D. Thacker of the Pure Jharia Colliery ; Mr. T. W. Tutwiler of the Tata Iron and Steel Company, Limited, Jamshedpur ; Mr. P. Hackforth, District Engineer, East Indian Railway, Dhanbad, and Mr. E. S. Hoernle, Additional Deputy Commissioner, Dhanbad (for permission to use the site at the Rifle Range). We wish also to thank all those who have kindly provided samples of coal for test purposes or who have assisted the work of the Committee in other ways. The experimental work described in this report has been carried out by and under the personal direction of Mr. D. Penman who has been assisted by Babus P. C. Bhattacharjee and B. B. Das.

Owing to absence in England Mr. J. H. Lang has not signed the report.



R. R. SIMPSON.
J. B. WARDLAW.
J. THOMAS.
H. C. READ.
P. BATES.
H. K. NAG.
G. NAYSMITH.
D. PENMAN.

DHANBAD :
5th May, 1924.

APPENDIX I.

Description of Coal-dust Test Gallery.

The coal-dust test gallery is situated on the Rifle Range, Dhanbad. It consists of a series of steel tubes* of different diameters rivetted and bolted together. (See Sketch). The tubes are laid on the ground and are not anchored in any way. The length of the gallery is approximately 160 feet. One end of the gallery is closed. A door is cut in the gallery at a point about 18 feet from the closed end in order to facilitate the charging of the cannon which is laid on the floor of the gallery at that point.

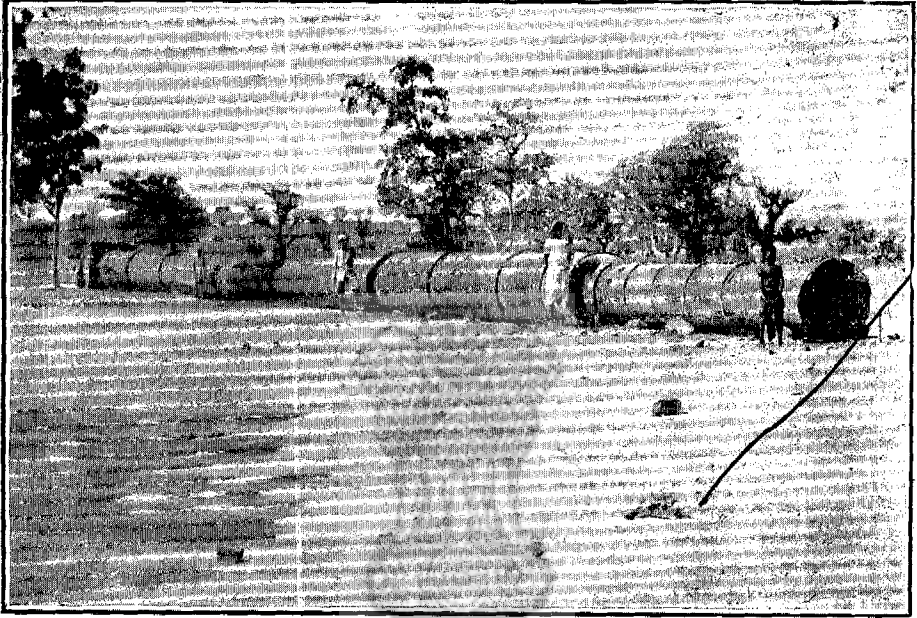
The cannon consists of part of a steel drum shaft $4\frac{1}{2}$ inches diameter having a hole 2 inches diameter and 24 inches deep. The coal to be tested is ground in a power-driven Hardy multiple grinder of the percussive type. The disintegration is effected by the percussive action of three sets of beaters working in three chambers of increasing diameter. The coal is first broken by hand into pieces about one inch to two inches cube and then fed into the smallest beating chamber of the grinder. The intensity of the percussive action increases in the second and third chambers and the coal is discharged in the form of fine dust. The machine has been installed at North Kustore Colliery belonging to the Raneegunge Coal Association. The colliery is about 4 miles distant from the test station. A magazine for the storage of explosives and a hut for the accommodation of coal samples, tools, etc., have been erected near the test gallery

*We are indebted to the following firms for the loan of the tubes :—

Messrs. Andrew Yule and Co., Calcutta.

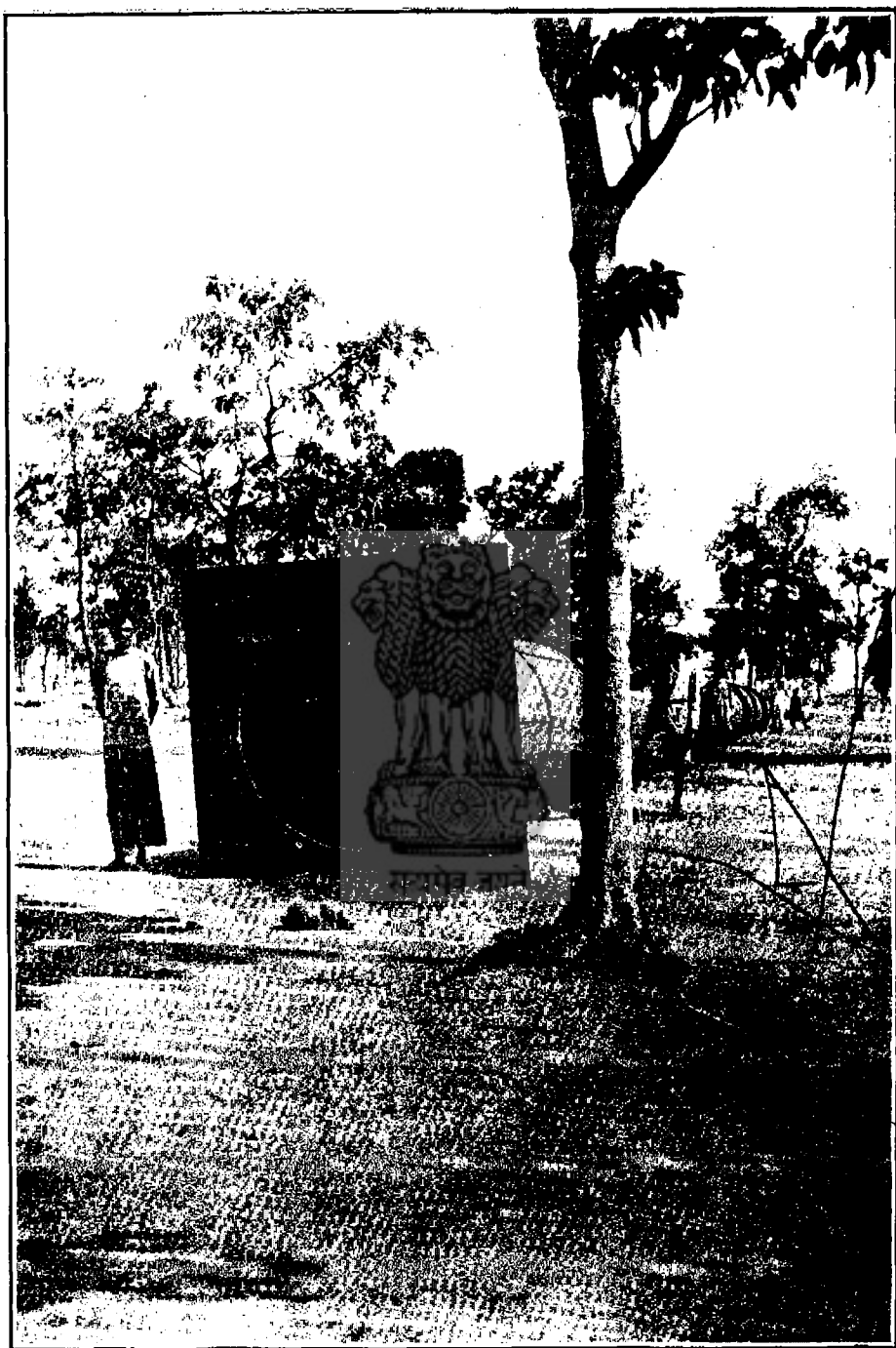
Messrs. the Tata Iron and Steel Co., Jamshedpur.

Messrs. the Equitable Coal Co., Calcutta.

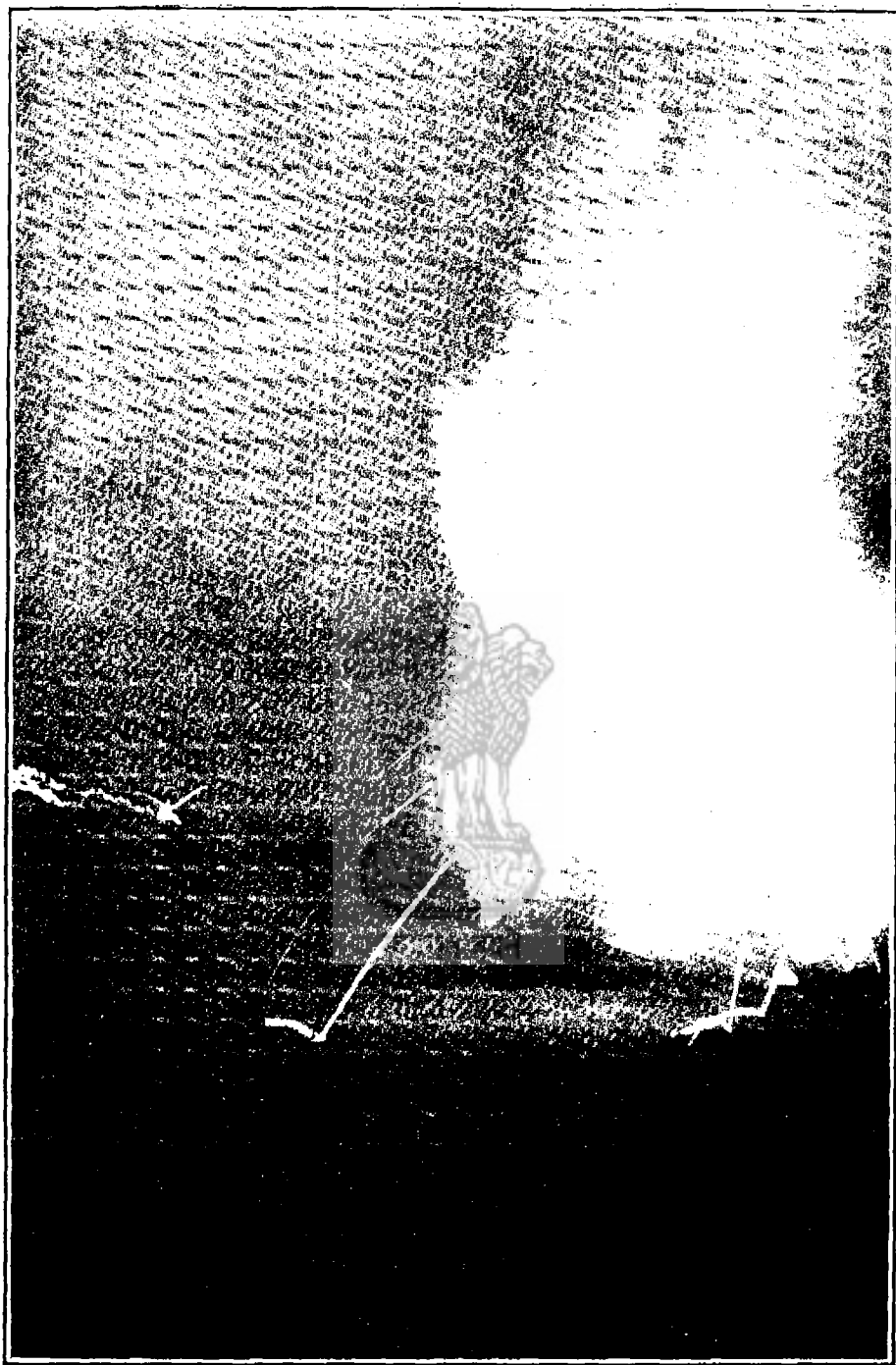


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The Experimental Gallery at Dhanbad viewed from the closed end.



The Experimental Gallery at Dhanbad viewed from the open end.

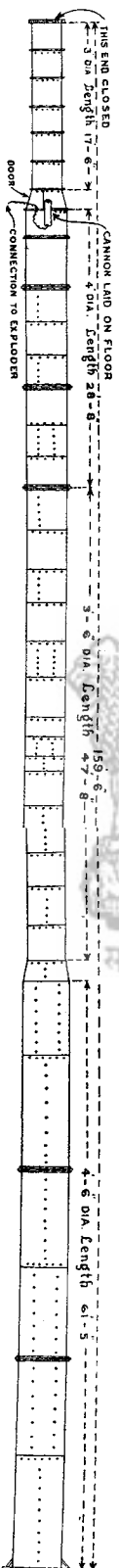


Flame of burning coal-dust issuing from mouth of Experimental Gallery.

The tracks of incandescent particles may be noted.

EXPERIMENTAL GALLERY FOR COAL DUST EXPLOSION TEST.

Scale 1 Inch = 8 Feet.



APPENDIX II.

Notes on a visit to the Mines Department Testing Station at Eskmeals, Cumberland, on August 19th-21st, 1923, by R. R. Simpson.

The Testing Station is situated on the sea coast amidst sand dunes from 20 to 40 feet in height. There are no buildings within $\frac{1}{4}$ mile of the spot.

The main explosion gallery consists of boilers, 7 feet 6 inches in diameter, joined together to form a continuous tube, 750 feet in length. It is not embedded or covered in any way. It is by no means explosion proof, for in a recent experiment with Arley coal-dust a section, 30 feet in length, at the open end was demolished and fragments were thrown to considerable distances. The pressures developed have on occasion exceeded 100 lb. per square inch. Plans have been drawn up for the construction of a tube, 4 feet 6 inches diameter, which will be better able to withstand the high pressures developed. It is under consideration whether this tube will be sunk in the ground, covered up or placed in the open.

The tube is open at one end and closed at the other. Formerly the closed end communicated through two right angle bends with a fan, but since the explosion which damaged the gallery some few weeks ago this section has been shut off by a blind flange. The fan was used only for cleaning the tube rapidly after an explosion. It was not kept running during an experiment.

Shelves are provided to contain the dust. These consist of planks, 6 inches $\times$ $\frac{1}{2}$ an inch, carried on angle iron brackets. They are not secured to the brackets. They are displaced by the explosions and many of them are blown out of the tube.

Dust is strewn on the shelves and the floor of the gallery at the rate of 1 lb. per linear foot up to a distance of 350 feet from the open end. Ignition is obtained by means of a charge of 24 ounces of blasting powder fired from a cannon placed 350 feet from the open end. The mouth of the cannon points into a tube, 3 feet diameter $\times$ 12 feet long, open at both ends and lying on the floor. This tube, known as the constriction or impetus tube, contains dust at the rate of 2 lb. per linear foot.

Props and bars are set in the gallery at distances of 30 feet, 70 feet and 120 feet from the cannon. Continuous recording pressure gauges and cameras are placed outside the tube, but in communication with it through small openings. These are in electrical connection with the firing station which consists of a separate boiler containing all the necessary recording and firing apparatus. This is about 200 feet from the tube.

Machinery, etc.

Three 33 kilowatt 200 volts Direct Current generating sets driven by Vickers-Petter oil engines.

Pulverizer by the Powdered Fuel Plant Company, Limited, consists of a cylinder, 2 feet 6 inches $\times$ 3 feet, containing hammer vanes with decreasing clearance up to a fan which blows the dust up through a tube into a hopper. Capacity 100 lb. of dust per hour at a fineness of 85 per cent. through 200 mesh (by sample). Fan for clearing tube is a Sirocco, 6 feet diameter, driven at 250 revolution by a 30 H. P. motor.

Accumulator set, 60 cells, giving 600 ampere hours.

Pressure gauges consist of B. C. D. manometers made by the Cambridge and Paul Instrument Company, Cambridge. Each requires 1-10 H. P. but could be worked by a falling weight.

Cannon of Low Moor Iron, 3 feet $\times$ 6 inches with 2 inches bore. Charge of 24 to 28 oz. blasting powder stemmed lightly with 8 oz. fireclay. Ignition by magneto exploder with 5 grains powder fuse. 4 inches of muzzle of cannon projects into constriction tube.

3 feet 6 inches tube.

There is also a second tube, 400 feet long, constructed of boiler flues. It has been chiefly used for gas and dust experiments but some dust experiments have been made.

Experiments in large Gallery.

I.—Dust from Black band seam, Scotland. No explosion.

II.—Same dust from Blackband seam, Scotland. Violent explosion with large flame outside tube.

III.—Same dust and 50 per cent. stone dust. Explosion, less violent, but considerable flame outside.

Conclusion.—That under certain conditions 50 per cent. of stone dust is not sufficient to prevent explosion of this coal-dust.

Experiments in 3 feet 6 inches tube.

I.—Length of tube 320 feet. Cannon 270 feet from open end. No constriction tube, $\frac{1}{2}$ lb. dust per linear foot. Charge 24 oz. blasting powder. No flame at mouth of tube, but skilled observer judging from warmth of tube thought that flame had extended about 75 feet from the cannon. The normal flame from the charge extends 20 to 30 feet from the cannon.

II.—Same conditions except that for 15 feet from cannon dust was spread on a plank at the rate of 2 lb. per linear foot. Charge 28 oz. blasting powder. No explosion.

III.—Records of three experiments made in 1913 with Silkstone dust.

Gallery 3 feet 6 inches by 400 feet. Dust $\frac{1}{2}$ lb. per linear foot.

(a) Cannon 20 feet from blank end. Flame 20 feet out of end.

(b) Cannon 25 feet from blank end. Flame 20 feet out of end.

(c) Cannon 50 feet from blank end. Flame 50 feet out of end.

Laboratory experiments.

These are fully described in the Report of the "Explosions in Mines" Committee. I witnessed a number of experiments with dust from the Blackband (Scotland) and Arley seams (Lancashire). A glass tube, 10 feet long and 4 inches diameter, open at both ends is used. Centrally in this tube and nearer the end from which the dust is introduced a platinum spiral is placed. This is heated to a known temperature by thermo-electric means. Temperatures from 980° C. to 1150° C. were employed. About

2 grammes of coal-dust is placed in a scoop at the end of and just outside the tube. This is blown into the tube by air compressed by a falling weight in a vertical cylinder. The coal dust is ignited by the glowing spiral and explodes in the tube. As a rule flame is emitted from the tube. In some cases two and three explosions can be seen whilst occasionally flame also passes backwards and emerges from the end of the tube where the dust is introduced.

This apparatus costs about £50 and by its means very instructive demonstrations can be given. As in the large scale experiments the results are not always consistent, but the comparative danger of different dusts can be measured as accurately as in the large scale experiments.

A capital expenditure of £50,000 has been incurred at the Eskmeals Testing Station, and £25,000 more is to be spent on improvements. The annual running cost is £13,000.

Notes on a visit to the Chanters pit, Atherton Colliery, Lancashire, on 13th September 1923 by R. R. Simpson.

The object of the visit was to see how stone dusting is carried on at the colliery.

The colliery is some 20 or 30 years old and fairly extensive, the faces being from one to $1\frac{1}{2}$ miles distant from the shafts. The output is about 2,000 tons per day, chiefly from the Arley seam.

Stone dusting has been in practice for about 10 years, and the quantity used is from 7 to 10 tons per week. Colliery shale is employed ; it is ground in mills to a fineness of about 150 to 200 mesh.

For spreading the dust in the mine machines were formerly employed, but have been discarded, as spreading by hand was found to be more effective and also cheaper. The stone dust is taken underground in tubs which are overturned by the side of the road at intervals of about 150 to 300 feet. From each heap a few shovelfuls is thrown into the air periodically and this is carried by the air current and deposited on the roof, sides, floor and timbering so as to maintain a mixture of dust containing less than 50 per cent of combustible matter.

The combustible content of the dust is ascertained by systematic sampling, but no rules have yet been issued as to the closeness of the sampling. At this colliery about eight samples per week were being taken. An Inspector of Mines who was present thought that to obtain any proper idea of the condition of the mine in respect of stone dusting several thousands of samples annually would be necessary. The manager protested against this as being impracticable and said that he thought he was taking more samples than are taken at other collieries.

Four samples were taken by the Inspector of Mines ; three of these were taken at a point on an airway from the roof, sides and floor separately ; the fourth was a mixed sample taken on a haulage road from roof, sides and floor together.

As is the custom the samples were sent in sealed tins to the Eskmeals station, and the results were :—

At this point the methane content of the air was 0.82 per cent.	}	Roof of return airway ..	17.1 per cent. combustible matter,
		Sides of same airway ..	20.7 per cent. combustible matter.
		Floor of same airway ..	21.0 per cent. combustible matter.

Roof, floor and sides of haulage road. . . 27.3 per cent. combustible matter.

The samples—each of about two lb.—were taken with a flat camel's hair brush, about 4 inches wide, and were collected in a small tray resembling a dust-pan. The taking of each sample occupied about an hour of arduous labour.

